2000

Barriers to AEEs: Interoperability of Systems and Tools

Zyda, Michael

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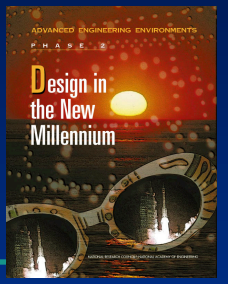

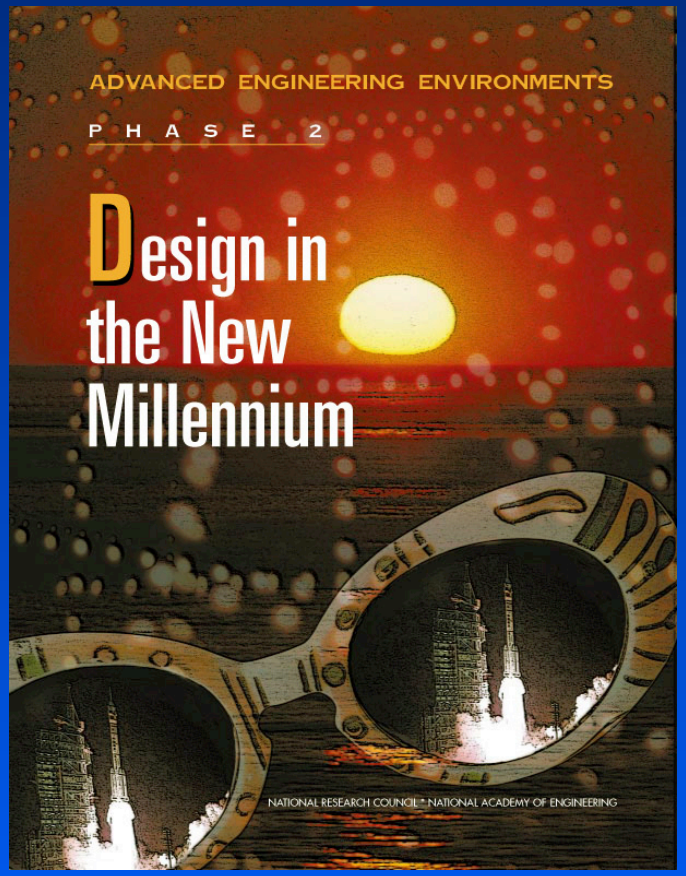

Barriers to AEEs: Interoperability of Systems & Tools

Michael Zyda
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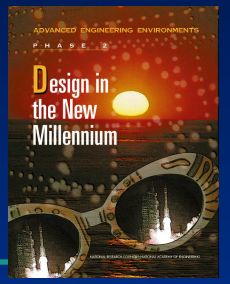
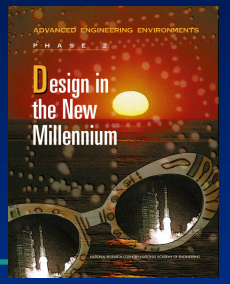
Integration of Tools &Systems



One of the most daunting, long-term barriers to establishing AEEs is the integration and portability of software tools for design and development across

- disparate operating systems, computer networks, and programming languages &
- governmental and corporate cultures.

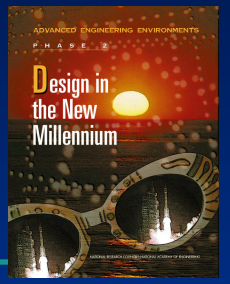
Solutions to interoperability & composability



AEEs of the future will require

- general solutions to interoperability (i.e., the ability of various systems to work together in a meaningful and coherent fashion) &
- composability (i.e., the ability to build new systems using components designed for existing systems) (NRC, 1997b).

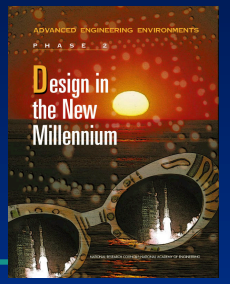
Monolithic tools - the current state-of-the-art ...



The current state of practice is typified by

- a proliferation of non-uniform software tools written by engineers working in isolation to solve discipline-specific problems,
- by tools that are monolithic rather than modularized in structure, and
- by special-purpose tools created by individual organizations for their own use.

Proprietary software & data formats

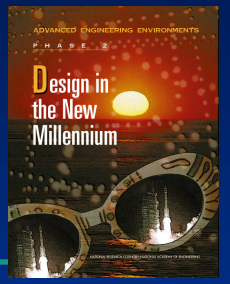


Competitive advantage or impediment to progress?

- Inhibit data exchange
- Don't allow tool interoperability.
- Data loss on exchange.
- How money is made?

Without interoperability, innovation is slowed and advances in tools may be counterproductive.

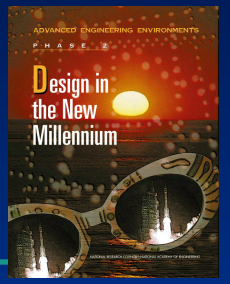
Composability facilitates



Composability would facilitate the development of AEE systems with

- more robust, reusable components and
- flexible structures that can evolve as technologies, users, and their organizations evolve.

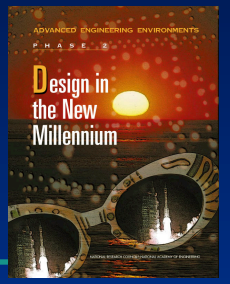
Composability begats reuse which diminishes reinvention



Reusable software modules would eliminate the need for each organization to develop the same tools.

- By packaging software for easy reuse, composability would also diminish the problems of monolithic software tools and systems.

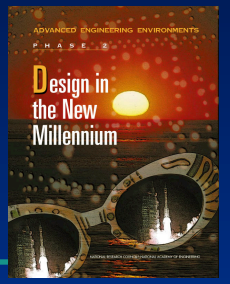
Moving to open source ...



Increasing the use of "open-source" guidelines is a promising approach for developing and implementing composable software (Raymond, 1999).

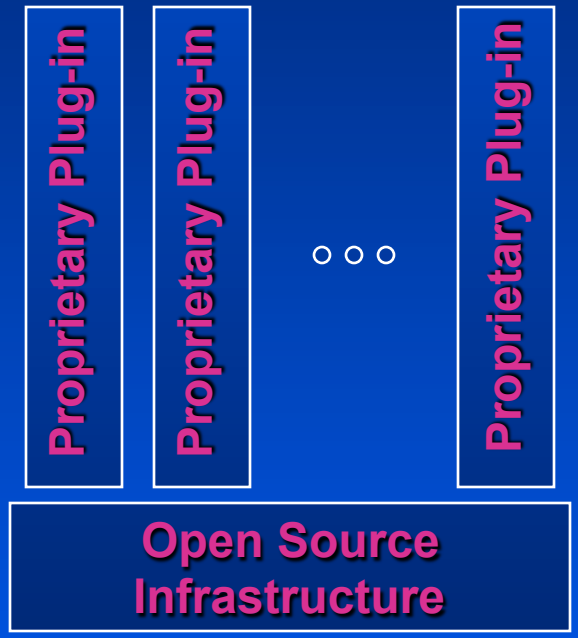
- Each software program's source code would be openly available via the Internet, with changes coordinated through on-line source-code control systems.

Competition-Sensitive Design & Development Software

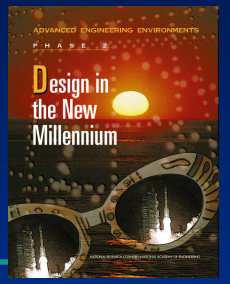


To address proprietary concerns,

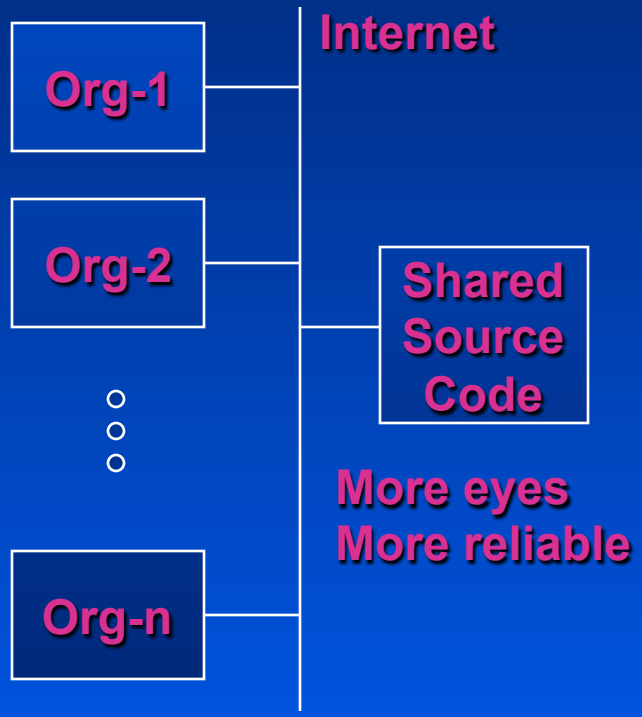
- Open-source guidelines could be used for infrastructure software that supports interoperability and composability,
- while limiting access to competition-sensitive functions.



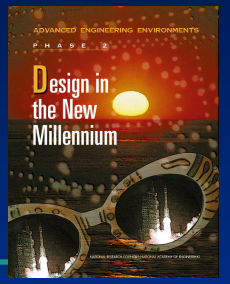
The open source concept



The concept behind open-source code is that many people and organizations will continually examine and improve the code, increasing its reliability.



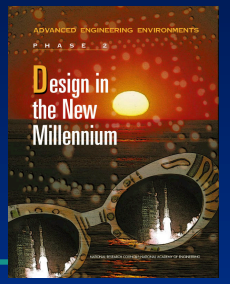
Engineers prefer open-source



Many engineers prefer open-source technology

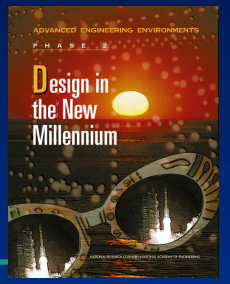
- they believe that they can correct problems more readily than with proprietary source codes that are owned and managed by individual corporations.

The Internet is THE medium for interoperability ...



The committee believes that the current trend toward using the Internet as a universal medium should be expanded to search for general, Internet-based solutions to complex tool interoperability.

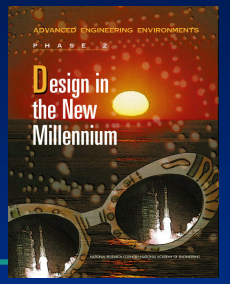
Ad hoc interoperability must die ...



Current ad hoc interoperability mechanisms tend to be governed either

- by the sharing of data files formatted in proprietary formats or
- by government mandates regarding the use of languages (such as Ada) and architectures (such as High Level Architecture).

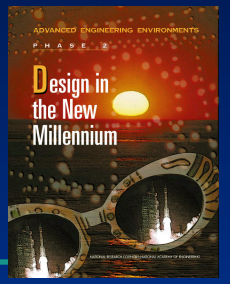
Government mandates hinder the use of more efficient software



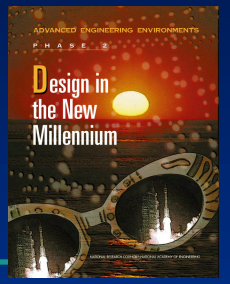
Government mandates may improve interoperability within a niche market controlled by the government,

- but they can also result in policies that isolate that market from the larger software community and unnecessarily hinder the use of more efficient software (NRC, 1997a).

Open Internet Computing - the Way to Interoperability



Basic research on interoperability should be supported in the flow of open Internet computing, open standards, industry-wide consortia, and other processes that have served the Internet so well.

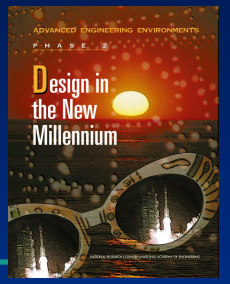


Finding 4-1

Interoperability and composability problems are a major barrier to realizing the AEE vision.

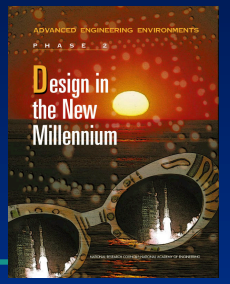
- The understanding of and technology base for developing interoperable and composable software architectures need to be improved.

Recommendation 4-1



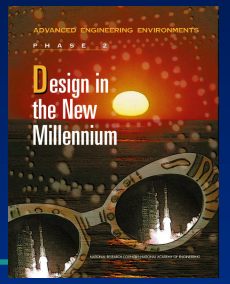
The federal government should support basic research on the interoperability and composability of component software architectures in the context of open Internet computing to increase software reliability and encourage the widespread use of promising solutions.

Recommendation 4-1



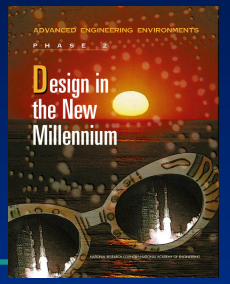
Efforts to resolve interoperability and composability problems should investigate approaches, such as open-source guidelines, for bringing together software designed for diverse applications (e.g., mechanical, electrical, software, and biomedical systems).

Recommendation 4-2



Government, industry, and academia should seek consensus on interoperability standards.

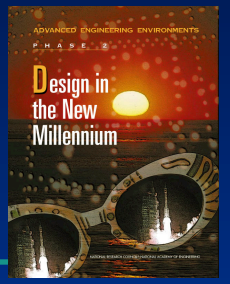
Multiple Hardware Platforms & Operating Systems



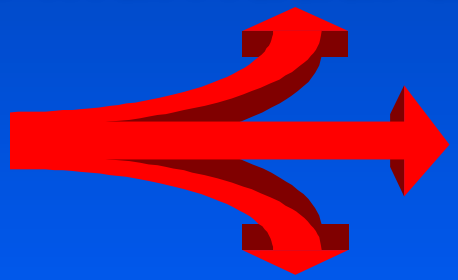
Assuming that the transition to Internet computing continues and that basic research in interoperability and composability proceeds,

- fewer choices for operating systems are likely to be available in 15 years.

Open-source successor to Java

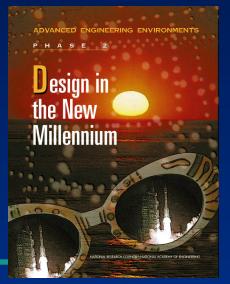


The committee believes that, in the future, an open-source successor to Java is likely to dominate, becoming the primary interface with the underlying operating systems embedded in the hardware of individual users.



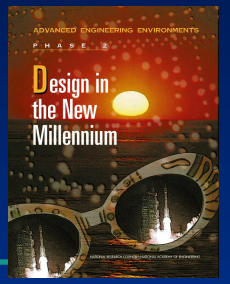
JAVA++?

Operating systems out of corporate & govt control



The underlying operating systems will be much simpler than current operating systems and will probably have achieved prominence by acclamation and adoption, rather than by government mandate or corporate control.

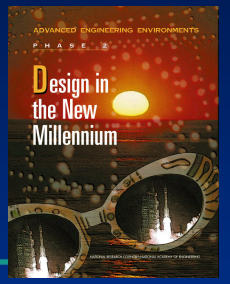
Finding 4-2



Engineering tools and systems have been developed on a variety of incompatible operating systems and with a variety of programming languages.

This situation is changing as more advanced tools and systems are being developed for Internet deployment.

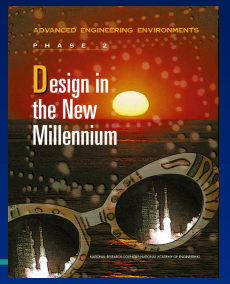
Data visualization begats virtual environments



The most likely means of improving existing capabilities for data visualization is within the framework of multimodal display and interaction.

- Haptics, Spatial Audio, Olfaction, ...

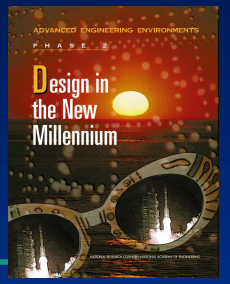
Government investment directions



In the long term, the government could enhance the management of large amounts of information by conducting basic research in several areas, including

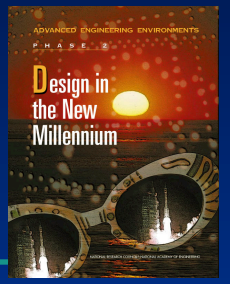
- multidimensional data visualization (i.e., visualization of data that contains more than four dimensions) and
- multisensory display and interaction.

Recommendation 4-3



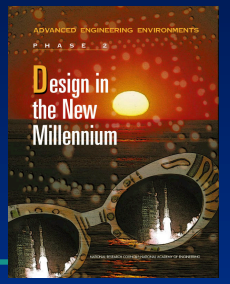
Research and development by the federal government on the visualization of engineering and scientific data should focus on long-term goals that go beyond those of ongoing research and development by industry.

Data communications



Communicating large amounts of engineering data quickly and reliably requires hardware and software infrastructures that are uniform and ubiquitous.

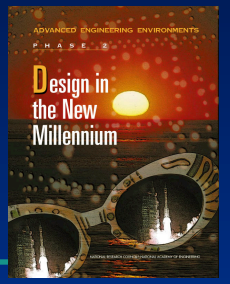
High-bandwidth, low-latency networks



The AEE vision requires that data be accessible, in quantity, from any location and that interaction with that data be instantaneous in human terms.

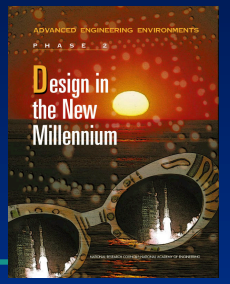
- This presupposes that all engineers have desktop access to high-bandwidth, low-latency networks.

Data transmission is not an AEE problem

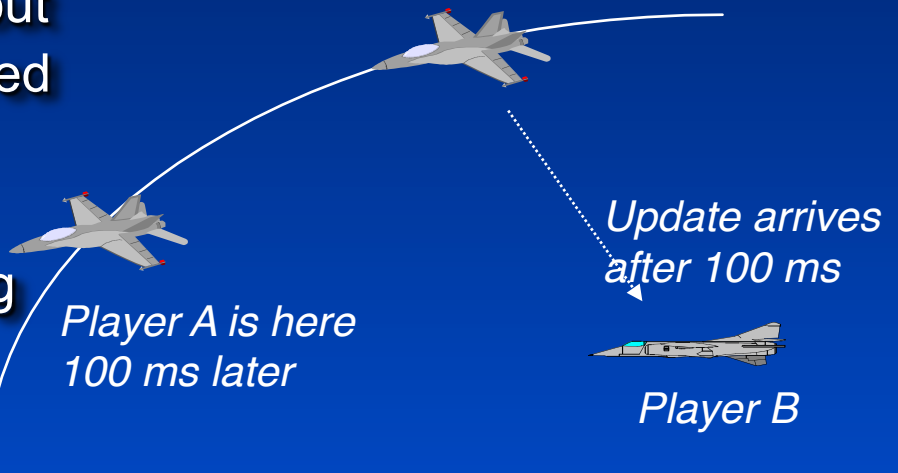


Assuming that AEE requirements will not be significantly larger than the commercial applications that will drive the deployment of the Internet of the future and other new data transmission systems, data transmission will not be a significant constraint on the deployment of future AEEs.

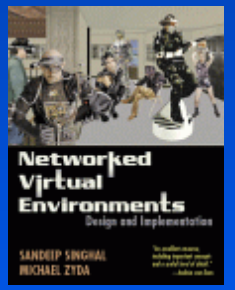
Improving latency may be more challenging



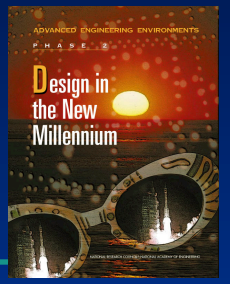
- A latency of less than about 100 milliseconds is required to create a three-dimensional, networked virtual world without losing the illusion of presence.



- Speed-of-light limitations impose a latency of at least 8.25 milliseconds per time zone, which is then increased by latency in the responsiveness of sensors, processors, transmission equipment, displays, and systems (Singhal/Zyda, 1999).



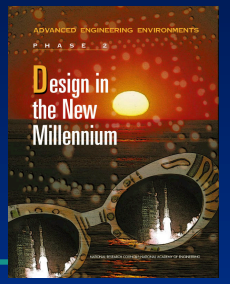
Where are high-bandwidth, low-latency nets?



1 billion hosts will be on line by 2005. About 60 percent of hosts are in the United States!

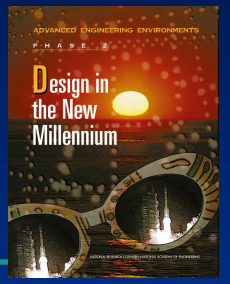
- Internet-2, the Next Generation Internet (NGI), & the very high performance Backbone Network Service (vBNS) are where this work is happenin

Finding 4-3



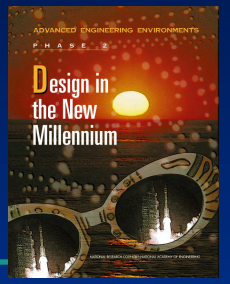
Advanced Internet technologies and applications are likely to provide the universal, high-bandwidth, low-latency communications network necessary to meet most communications needs for AEEs.

Recommendation 4-4



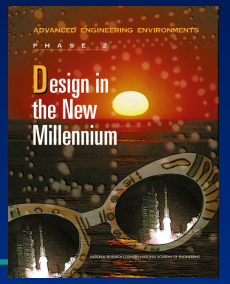
Research, development, and engineering organizations in government, industry, and academia should ensure that technical staff and students have access to advanced data communications networks as those systems become available.

Security of data



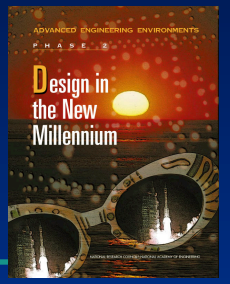
A central aspect of the committee's vision for AEEs is ubiquitous access of the entire engineering team to relevant data, and a sophisticated system for managing access control is essential.

Cumbersome access controls will not work ...



Access controls must not be too rigorous or cumbersome, however, because the entire engineering process can be disrupted if data are not available or if significant delays or complex processes are involved in accessing data.

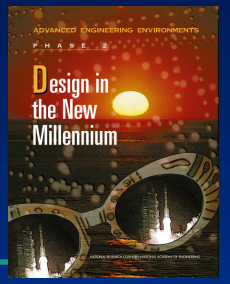
Recommendation 4-5



The government and academia should conduct research to improve understanding of the following topics:

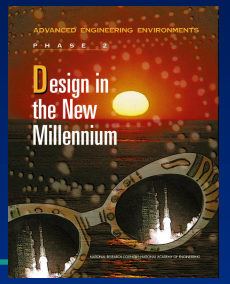
- the role of physical artifacts in supporting collaborative design processes and how that role can be fulfilled when physical artifacts are replaced by simulations, virtual objects, avatars, and other nonphysical artifacts

Recommendation 4-5 cont.



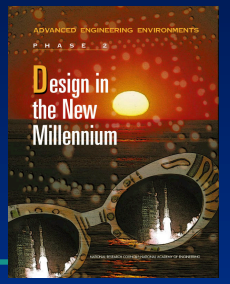
- Methods for designing AEE systems that accommodate workers with a variety of work styles and improve the new work environment (e.g., by improving situational awareness for workers transitioning between tasks, teams, and projects)
- The psychological and temporal dimensions of engineering design work in synchronous, distributed collaborative activities, especially if team members are located in multiple time zones and work for organizations with different cultures and business goals.

Finding 4-4

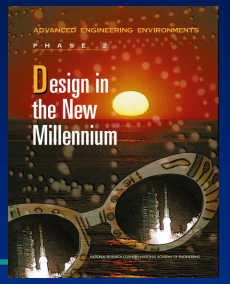


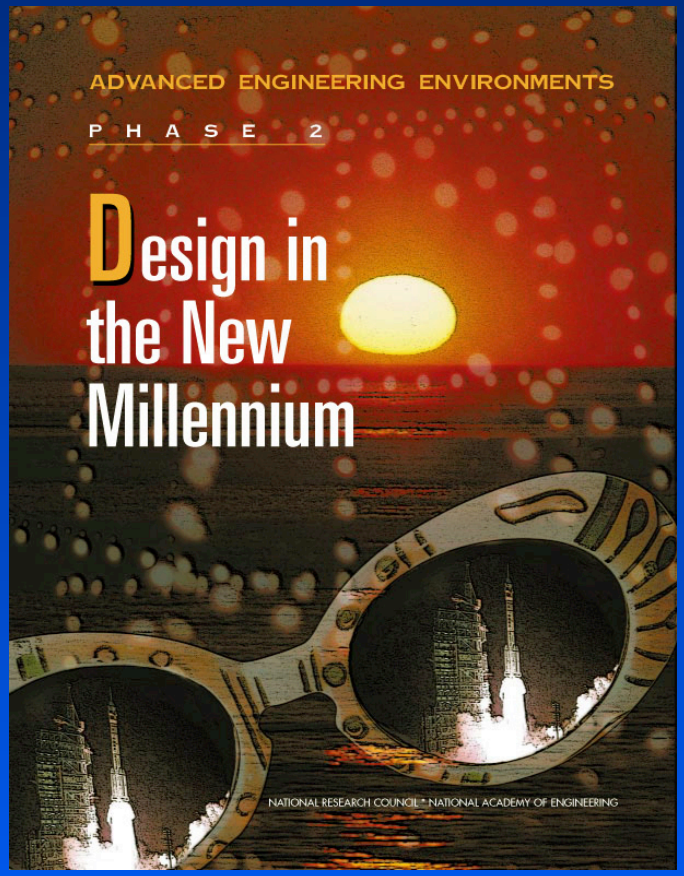
Research funding, interdepartmental cooperation, and organizational support for interdisciplinary programs has traditionally been difficult to obtain from the government or academia, largely because funding agencies have usually set narrow limits on the types of projects they are willing to support.

Recommendation 4-7



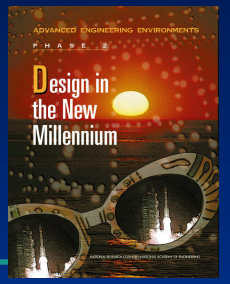
Universities should appoint AEE champions to provide strong, long-term leadership for implementing AEE technologies and systems; establish the innovative, interdisciplinary educational programs and faculty needed to take full advantage of the capabilities of AEEs; increase the emphasis in undergraduate and graduate education on the scholarship of integration and application; and develop curricula with a stronger foundation in software development, including component software architecture, composability, and interoperability.





- Where to get the NRC report “Advanced Engineering Environments Phase 2 - Design in the New Millennium”
- National Academy Press
  - http://www.nap.edu
  - 800-624-6242

Any questions?



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